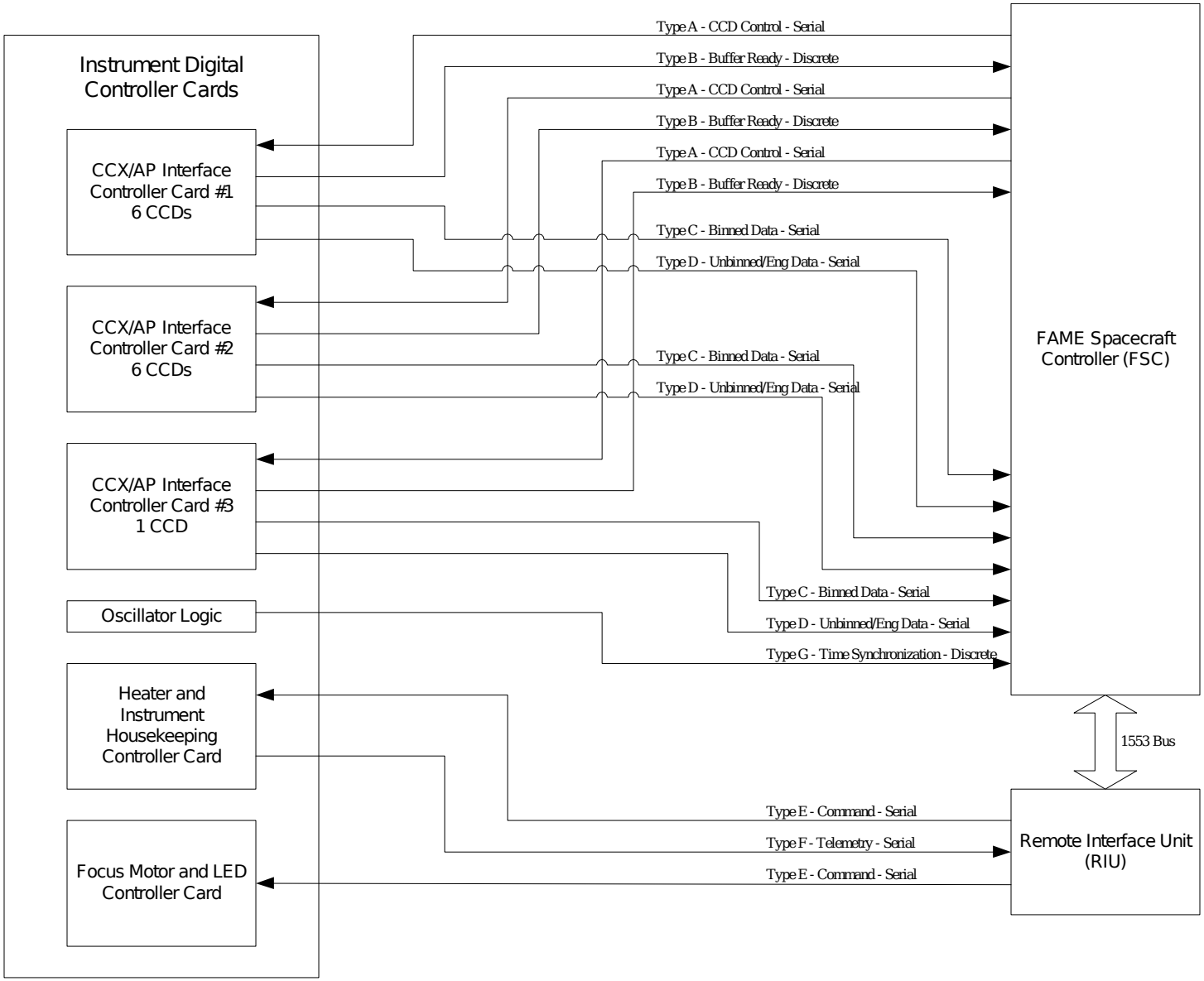
Bus/Instrument Control & Data Interface

9/19/2001

Interface Summary



Interface List

Type	Name	Signal				Wire Count	Word Size (bits)	Clock Rate Hz
		1	2	3	4			
A	CCD Control	Clock	Data	Enable	-	6	33	>2,000,000 (TBR)
B	Buffer_Ready	CTS	-	-	-	2	-	~0.50
C	CCD Binned Data	Clock	Data	Enable	Channel_Act	8	64	12,500,000
D	CCD Unbinned Data	Clock	Data	Enable	Channel_Act	8	64	12,500,000
E	Instrument Command	Clock	Data	Enable	-	6	17	125,000
F	Instrument Telemetry	Clock	Data	Enable	-	6	16	125,000
G	Time_Epoch	Clock	-	-	-	2	-	~0.10

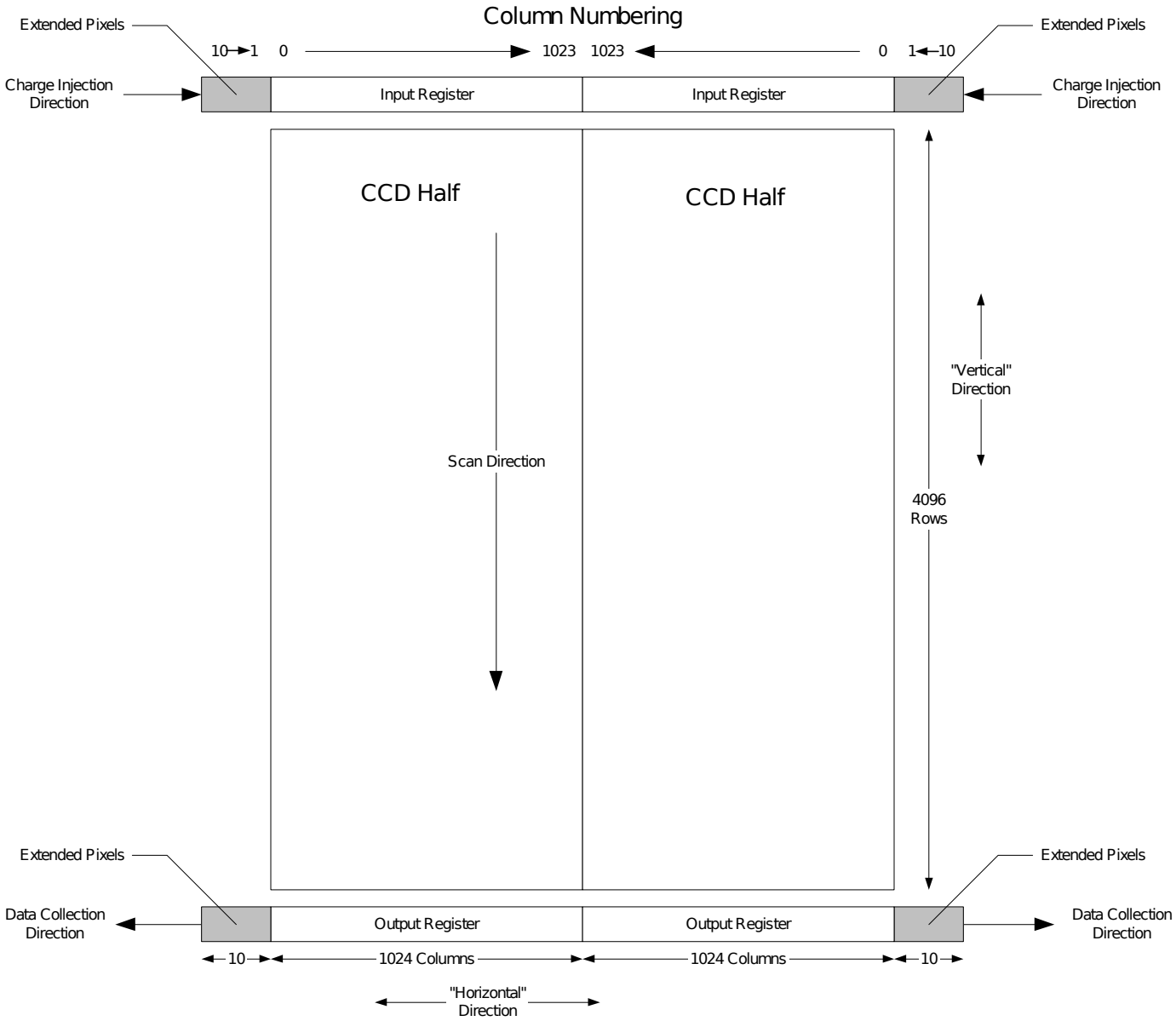
Notes:	Types A, C, D, E, F	At least one clock cycle is required between words (enables)
	Type A, C, D, E, F	Msbit first
	Type A	Odd Parity, Parity Bit is last bit transmitted per word
	Type B	Buffer Ready (clear to send) is active for the duration while the buffer is available for loading
	Type C	Channel Active will remain active on the binned data interface for the duration of a buffer download
	Type C	Channel Active will become active 300 micro-seconds (TBR) prior to transmission of binned data
	Type D	Channel Active will remain active on the unbinned/engineering data interface for the duration of each frame
	Type D	Channel Active will become active and envelope each frame with a minimum of TBD clock cycles between frames
	Type E	Odd Parity, Parity Bit is first bit transmitted per word

Interface Wire Count

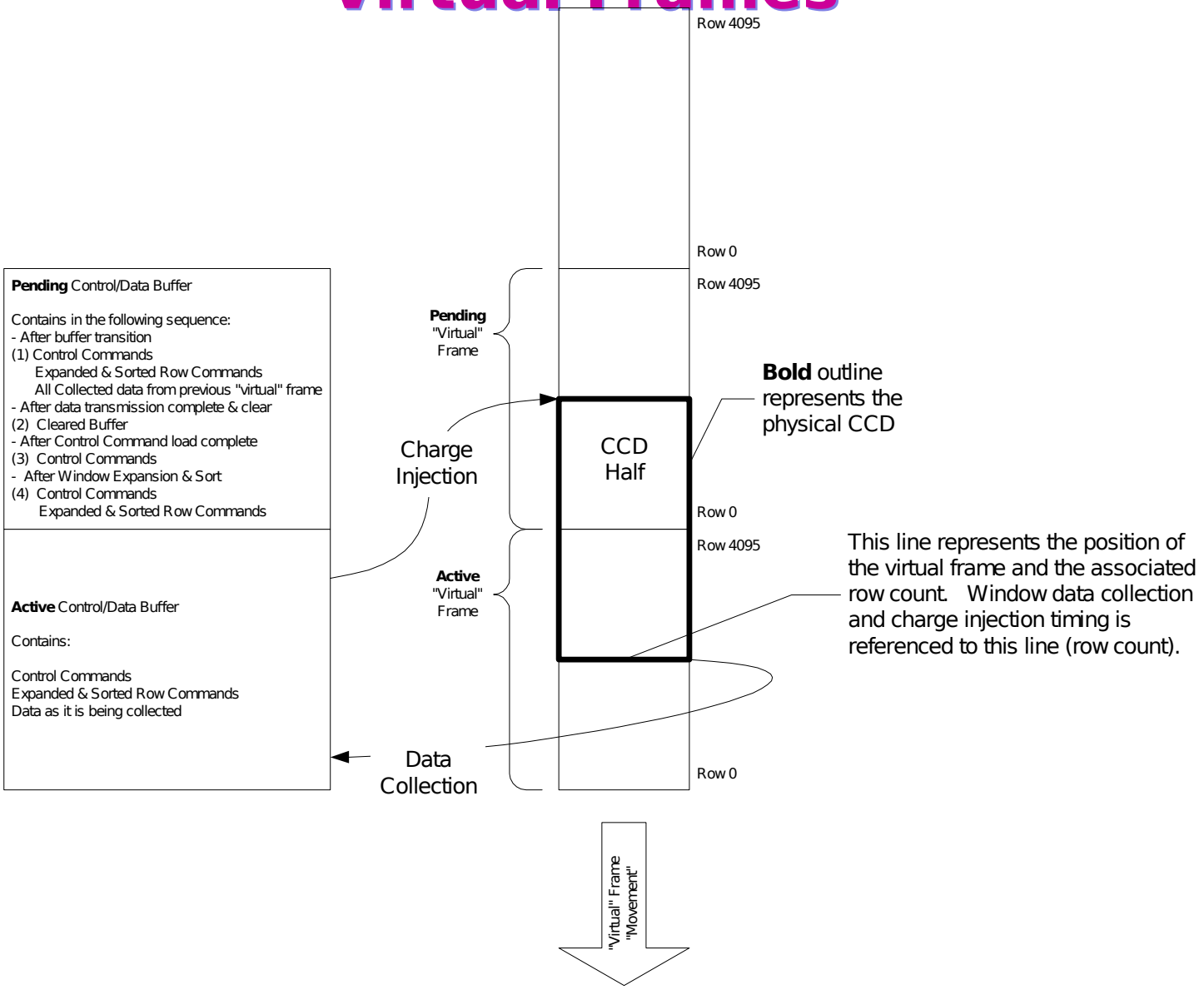
From	To	Type	Wire Count
FSC	CCX/AP IF Controller Card #1	A	6
CCX/AP IF Controller Card #1	FSC	B	2
CCX/AP IF Controller Card #1	FSC	C	8
CCX/AP IF Controller Card #1	FSC	D	8
FSC	CCX/AP IF Controller Card #2	A	6
CCX/AP IF Controller Card #2	FSC	B	2
CCX/AP IF Controller Card #2	FSC	C	8
CCX/AP IF Controller Card #2	FSC	D	8
FSC	CCX/AP IF Controller Card #3	A	6
CCX/AP IF Controller Card #3	FSC	B	2
CCX/AP IF Controller Card #3	FSC	C	8
CCX/AP IF Controller Card #3	FSC	D	8
RIU	Heater & Inst HK Controller Card	E	6
Heater & Inst HK Controller Card	RIU	F	6
RIU	Focus Motor & LED Controller Card	E	6
Oscillator Control Logic	FSC	G	2
		Total	92

CCD Control Interface

CCD Layout


Column Numbering
Extended Pixels
10 1 0
1023 1023
0 1 10
Extended Pixels
Charge Injection Direction
Input Register
Input Register
Charge Injection Direction
CCD Half
CCD Half
"Vertical" Direction
Scan Direction
4096 Rows
Extended Pixels
Extended Pixels
Data Collection Direction
Output Register
Output Register
Data Collection Direction
10
1024 Columns
1024 Columns
10
"Horizontal" Direction

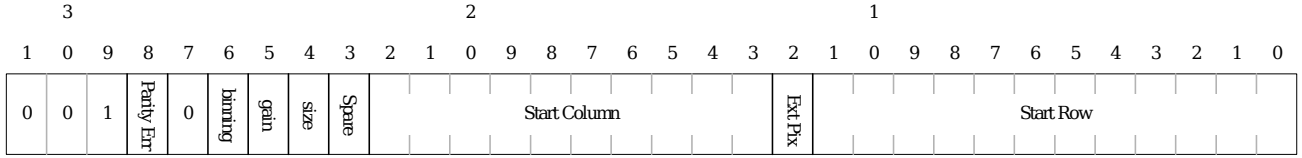
CCD Command Buffers & Virtual Frames



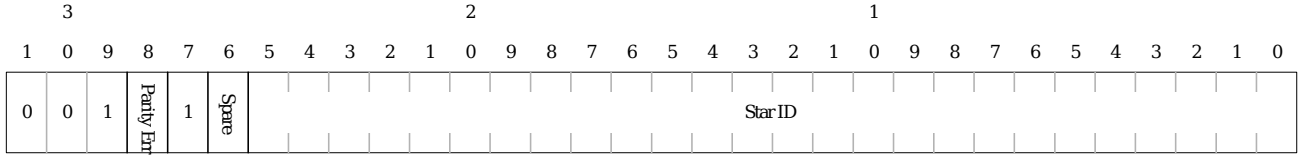
CCD Control - Commands (1 of 2)

CCD_HALF_SELECT

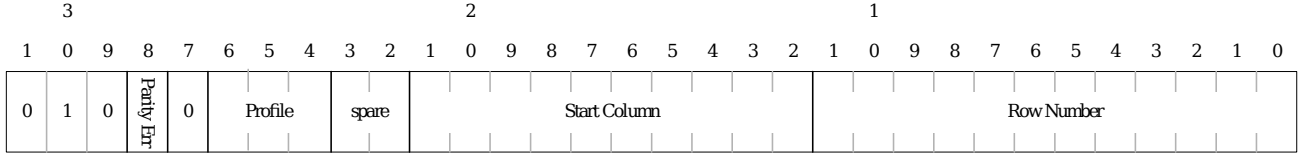
WINDOW



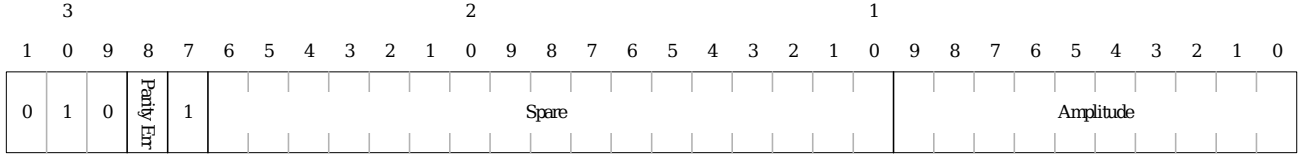
STAR_ID



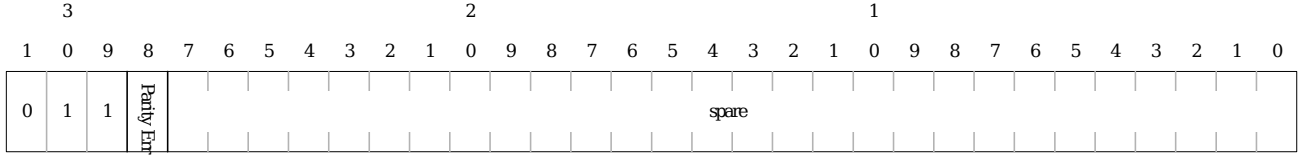
CHARGE_INJECTION



CHARGE_AMPLITUDE

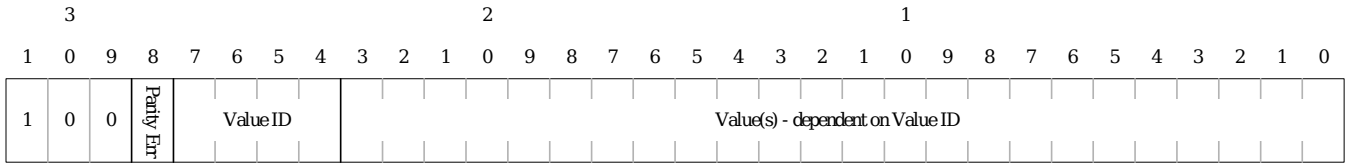


END_OF_DATA

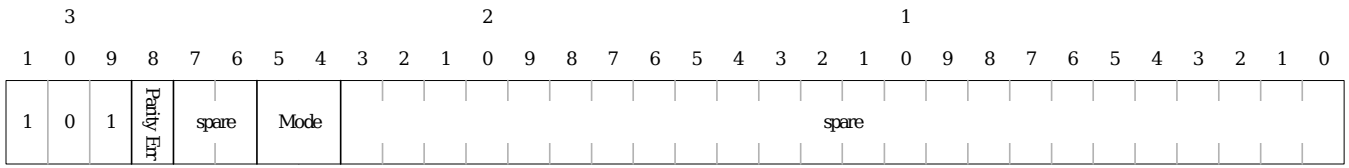


CCD Control - Commands (2 of 2)

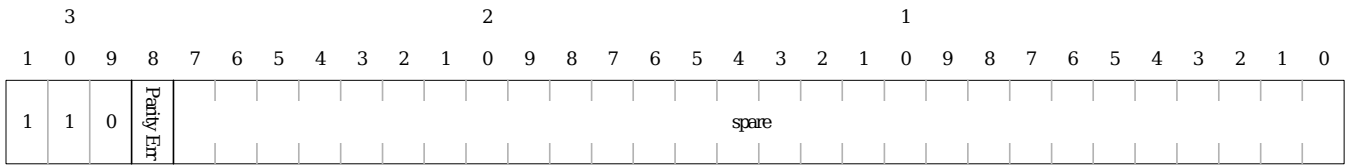
SET



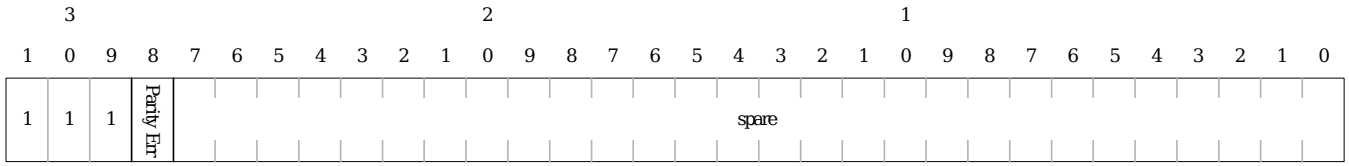
MODE



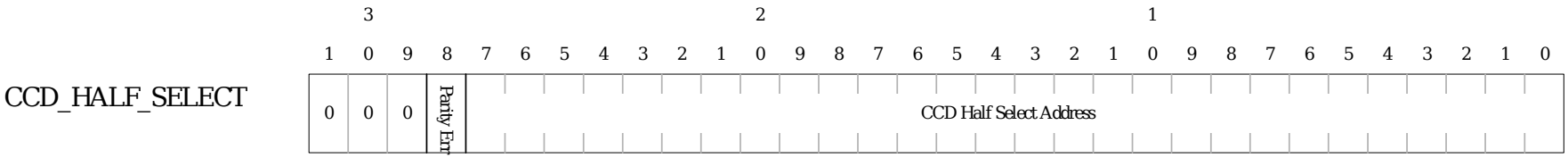
SPARE_CMD_1



SPARE_CMD_2

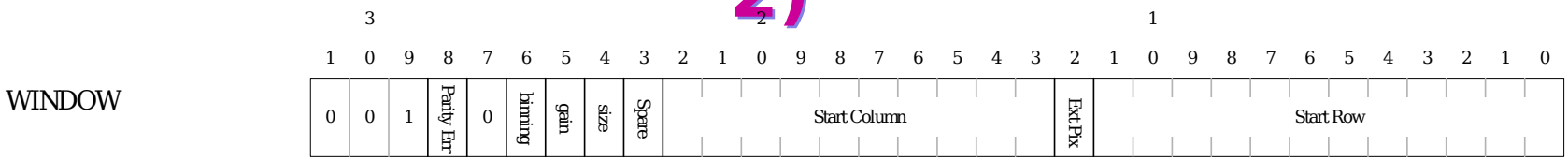


CCD Control - CCD_HALF_SELECT



- **Description: The CCD_HALF_SELECT command is used to select the CCD half. Each CCD half per CCX/AP interface card has a unique address. The CCD_HALF_SELECT command must precede all WINDOW and CHARGE_INJECTION commands intended for the CCD half for the next 4096 row period.**
- **Mode: Science**
- **Fields:**
  - **CCD Half Select Address**
    - **28 bits**
    - **Range:**
      - **CCD/AP IF 1, CCD_HALF 1: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 2: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 3: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 4: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 5: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 6: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 7: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 8: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 9: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 10: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 11: 0xnnnnnnn**
      - **CCD/AP IF 1, CCD_HALF 12: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 1: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 2: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 3: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 4: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 5: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 6: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 7: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 8: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 9: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 10: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 11: 0xnnnnnnn**
      - **CCD/AP IF 2, CCD_HALF 12: 0xnnnnnnn**
      - **CCD/AP IF 3, CCD_HALF 1: 0xnnnnnnn**
      - **CCD/AP IF 3, CCD_HALF 1: 0xnnnnnnn**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

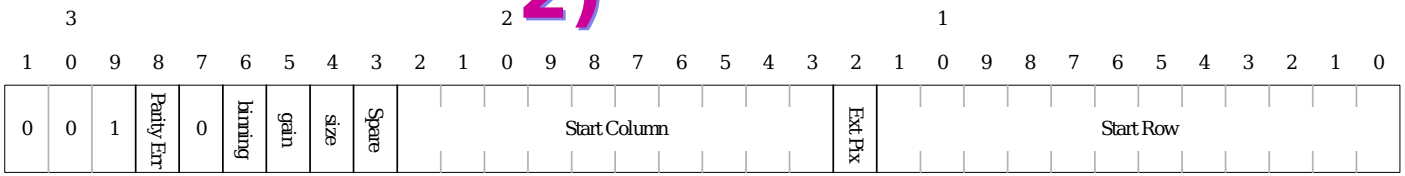
CCD Control - WINDOW (1 of 2)



- **Description: While in science mode, the WINDOW command is used to collect binned and unbinned science data. While in acquisition mode, the WINDOW command is used to collect acquisition images. While in engineering mode, the WINDOW command is used to collect raw CCD data.**
- **Modes: Science, Acquisition and Engineering**
- **Constraints:**
  - **Windows must not overlap each other**
    - **Overlap behavior will result in leading window to contain zero data in the overlap area, while the trailing window will be complete - TBR.**
  - **Windows must not extend past the CCD half edge**
    - **Windows extending past the edge will contain zero data in for that portion - TBR.**
  - **Windows must not extend past the end of a virtual frame**
    - **Windows extending past the end of a virtual frame will contain zero data in for that portion - TBR.**
  - **Each WINDOW command is paired with and must be immediately followed by an associated STAR_ID command.**
  - **The WINDOW commands for each CCD Half over a 4096 row period must be grouped together and must follow a CCD_HALF_SELECT command.**
  - **The WINDOW/STAR_ID command pairs can be intermixed with CHARGE_INJECTION/CHARGE_AMPLITUDE command pairs.**
  - **The WINDOW and CHARGE_INJECTION commands for a CCD Half can be issued in any sequence (no column or row sorting is required).**
  - **Number of window commands are limited to 511 commands**
  - **While in acquisition command, windows on the same CCD half cannot overlap with respect to row number.**
- **Note: The CCX/AP IF controller maintains a row number count that ranges from 0 to 4095 and increments once for each CCD row interval. The counter value identifies the data collection row (“bottom”) of the CCD half. The WINDOW Start Row number identifies the row number count used to identify the first window data collection row as it reaches the “bottom” of the CCD.**

CCD Control - WINDOW (2 of 2)

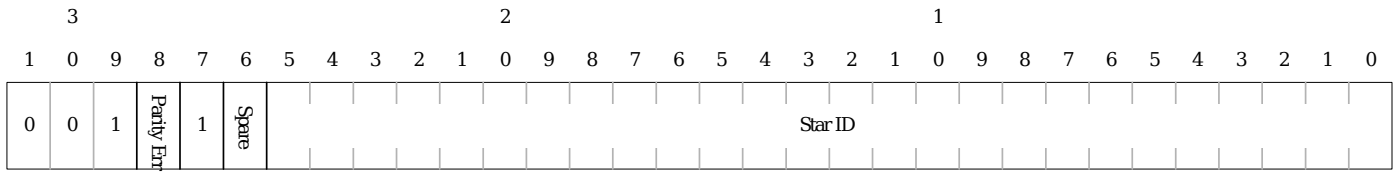
WINDOW



- **Fields:**
  - **Start Row - First Row of the window**
    - **12 bits**
    - **Range: 0 to (4095 - vertical_size_of_window)**
  - **Extended Pix - Extended Pixel Select**
    - **1 bit**
    - **Range:**
      - **0: Extended Pixel Select**
      - **1: Normal Data Select**
  - **Start Column - First Column of the window**
    - **10 bits**
    - **Range for Extended Pixel Select:**
      - **0**
    - **Range for Normal Data Select**
      - **0 to (1024 - horizontal_size_of_window)**
  - **Size - Window size select**
    - **1 bit**
    - **Range:**
      - **0: Window size 0 select**
      - **1: Window size 1 select**
  - **Gain - Gain select**
    - **1 bit**
    - **Range:**
      - **0: low gain setting**
      - **1: high gain setting**
  - **Binning - 1d or 2d select**
    - **1 bit**
    - **Range for Science Mode:**
      - **0: 2d select (resulting per row data production is 1/2 the horizontal window size)**
      - **1: 1d select (resulting per row data production is 1 value)**
    - **Range for Acquisition Mode:**
      - **2d select is mandatory in acquisition mode and must be set to 0.**
    - **Range for Engineering Mode:**
      - **Binning is not available in engineering mode and must be set to 0.**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - STAR_ID

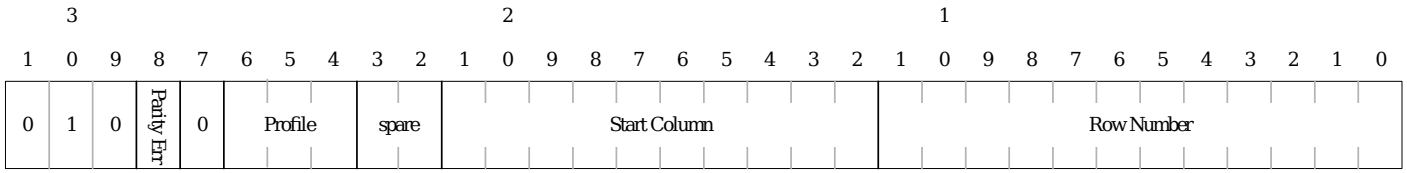
STAR_ID



- **Description: The STAR_ID command is used to identify, for ground processing purposes, the binned and unbinned science data, acquisition data and engineering data.**
- **Mode: Science, Acquisition, Engineering**
- **Constraints:**
  - **Each STAR_ID command is paired with and must immediately follow a WINDOW command.**
- **Fields:**
  - **Star ID - Star Identifier**
    - **26 bits**
    - **Range: 0 to 67,108,865**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

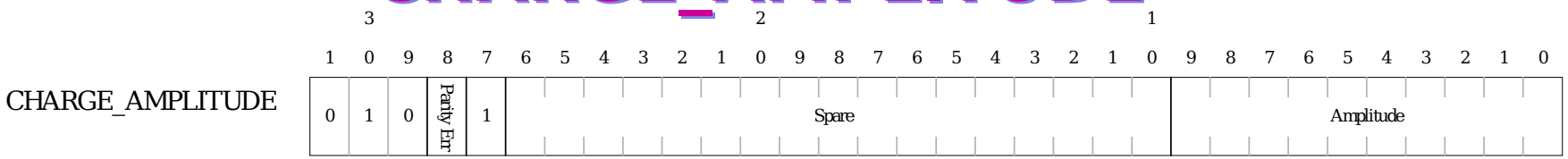
CCD Control - CHARGE_INJECTION

CHARGE_INJECTION



- **Description: The CHARGE_INJECTION command is used to apply a "horizontal" segment of charge at the "top" of the CCD. This charge is intended to precede binned and unbinned science data collection window while in science mode. This charge can be used to precede acquisition data collection window while in acquisition mode.**
- **Modes: Science, Acquisition, Engineering**
- **Constraints:**
  - **Windows must not extend past the CCD half edge.**
  - **Charge injection commands can overlap. Where the charge injection commands overlap, then the maximum value of the overlapping profile values will be used (TBR).**
  - **Each CHARGE_INJECTION command is paired with and must be immediately followed by an associated CHARGE_AMPLITUDE command.**
  - **The CHARGE_INJECTION commands for each CCD Half over a 4096 row period must be grouped together and must follow a CCD_HALF_SELECT command.**
  - **The CHARGE_INJECTION/CHARGE_AMPLITUDE command pairs can be intermixed with WINDOW/STAR_ID command pairs.**
  - **The CHARGE_INJECTION and WINDOW commands for a CCD Half can be issued in any sequence (no column or row sorting is required).**
  - **The CHARGE_INJECTION commands must be timed to occur 4096+n rows prior to the WINDOW command used to collect the binned or unbinned science data window or acquisition window.**
  - **No charge injection on lines 0, 1 and 2 can be issued in conjunction with a 3 line FAT 0 command.**
- **Notes: The CCX/AP IF Controller maintains a row number count that ranges from 0 to 4095 and increments once for each CCD row interval. This counter value identifies the data collection row ("bottom") of the CCD half. The CHARGE_INJECTION command will introduce a charge injection at the top of the CCD when the Row Number matches the CCX/AP IF Controller row counter.**
- **Fields:**
  - **Row Number - Row select for the charge injection**
    - **12 bits**
    - **Range: 0 to 4095**
  - **Start Column - First Column of the charge injection**
    - **10 bits**
    - **Range: 0 to (1024 - profile length)**
  - **Profile - Charge injection profile select**
    - **3 bits**
    - **Range:**
      - **0: 9 columns, constant amplitude**
      - **1: 9 columns, 1 column peak**
      - **2: 10 columns, 2 column peak**
      - **3: 11 columns, 3 column peak**
      - **4: 12 columns, 4 column peak**
      - **5: 13 columns, 5 column peak**
      - **6: 14 columns, 6 column peak**
      - **7: 15 columns, 7 column peak**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

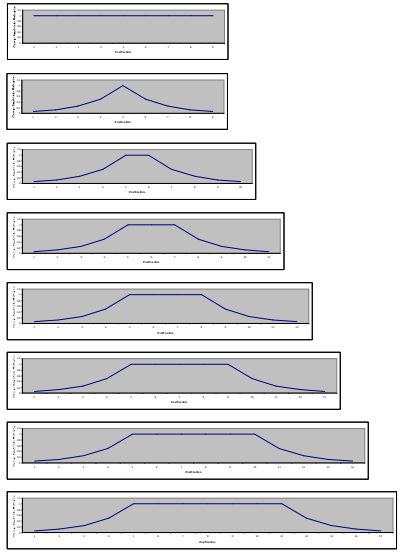
CCD Control - CHARGE_AMPLITUDE



- **Description: The CHARGE_AMPLITUDE command is used to control the amplitude setting of the charge injection segment. The amplitude setting represents the peak charge as defined by the profile.**
- **Modes: Science, Acquisition & Engineering**
- **Constraints:**
  - **Each CHARGE_AMPLITUDE command is paired with and must immediately follow a CHARGE_INJECTION command.**
- **Fields:**
  - **Amplitude - Charge injection amplitude (100 e/dn LSBit)**
    - **10 bits**
    - **Range: 0 to 1023**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

Charge Injection Profile

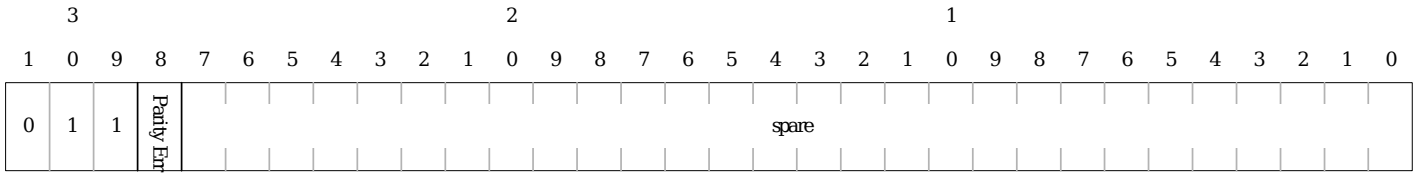
Profile Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Profile 0	0	0	0	0	0	0	0	0	0						
Profile 1	4	3	2	1	0	1	2	3	4						
Profile 2	4	3	2	1	0	0	1	2	3	4					
Profile 3	4	3	2	1	0	0	0	1	2	3	4				
Profile 4	4	3	2	1	0	0	0	0	1	2	3	4			
Profile 5	4	3	2	1	0	0	0	0	0	1	2	3	4		
Profile 6	4	3	2	1	0	0	0	0	0	0	1	2	3	4	
Profile 7	4	3	2	1	0	0	0	0	0	0	0	1	2	3	4



- **The Charge Injection for a profile position is determined by the following calculation:**
  - **Charge_Amplitude * (1 / $2^{Profile\_Value}$)**

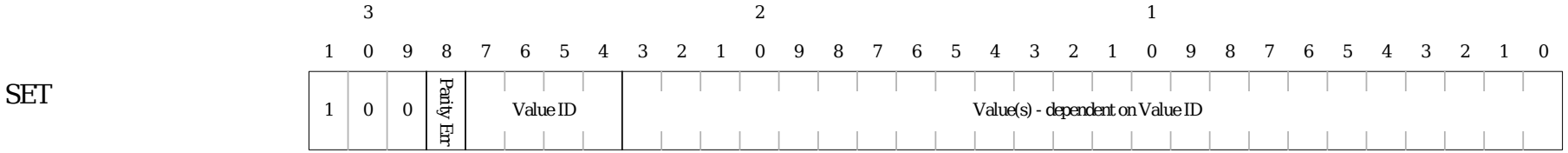
CCD Control - END_OF_DATA

END_OF_DATA



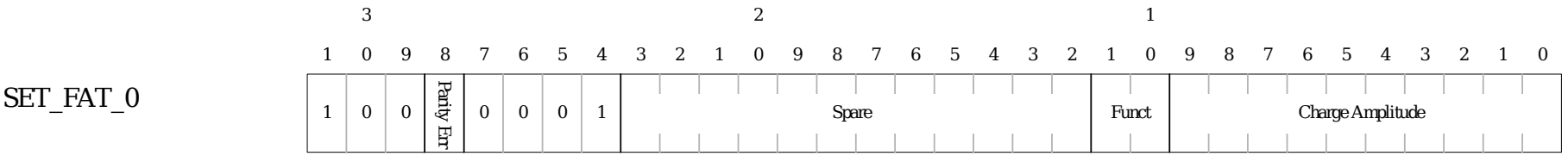
- **Description: The END_OF_DATA command is used to indicate to a CCX/AP IF Controller that all control commands for all associated CCD Halfs have been loaded and are ready for window expansion and sorting.**
- **Mode: Science, Acquisition, Engineering**
- **Fields:**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - SET



- **Description: The SET Command is used to set various CCX/AP Interface Controller configuration values. The SET commands will not affect the currently active command buffer. A SET command will take effect when the command buffer it is loaded into becomes active.**
- **Mode: Science, Acquisition, Engineering**
- **Fields:**
  - **Value ID**
    - **5 bits**
    - **Range:**
      - **Value ID 0: Spare**
      - **Value ID 1: SET_FAT_0 - FAT 0 Control**
      - **Value ID 2: SET_WIN_SIZE_0 - Window Size 0**
      - **Value ID 3: SET_WIN_SIZE_1 - Window Size 1**
      - **Value ID 4: SET_DIAGNOSTIC - Control Diagnostics**
      - **Value ID 5: SET_FRAME_DELAY - Control CCX/AP IF Card Synchronization**
      - **Value ID 5 through 15: Spare**
  - **Value fields are dependent on the Value ID**
    - **24 bits available**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

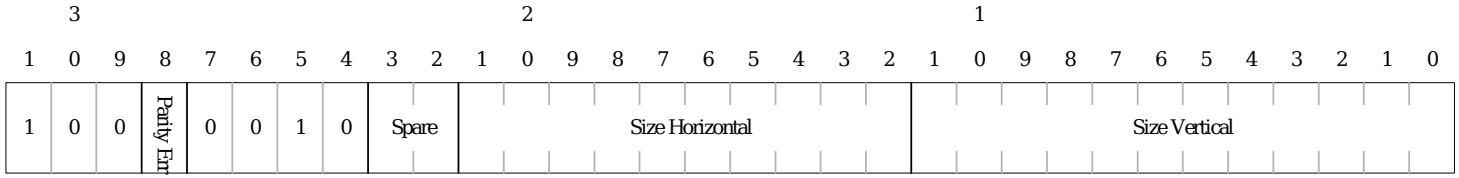
CCD Control - SET_FAT_0



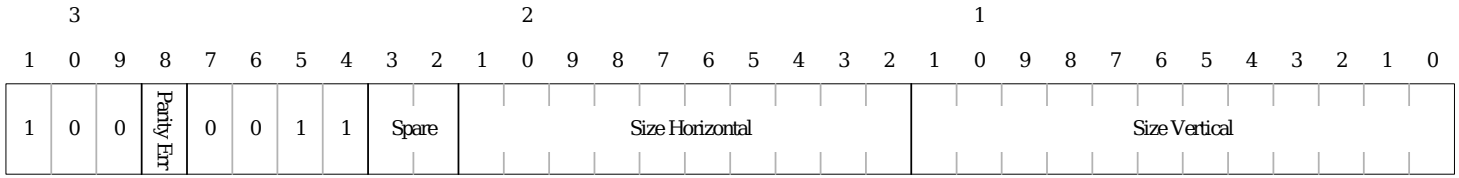
- **Description: The SET_FAT_0 Command is used to control the FAT 0 functions of the instrument. The FAT 0 control can be used to levy a charge across the entire CCD, 3 lines of the CCD or disable the FAT 0 function. The 3-Line FAT 0 function is always applied to rows 0, 1 and 2.**
- **Modes: Science, Acquisition, Engineering**
- **Contraints:**
  - **This command must immediately follow a CCD Half select.**
  - **One occurrence of each command per CCD Half.**
- **Fields:**
  - **Charge Amplitude - 100 e/dn LSBit**
    - **10 Bits**
    - **Range for Full and 3-Line function:**
      - **0 to 1023**
    - **Range for Off Function**
      - **Mandatory value of 0**
  - **Funct - FAT 0 Function Select**
    - **2 bits**
    - **Range:**
      - **0: FAT 0 Off**
      - **1: FAT 0 on Full CCD**
      - **2: FAT 0 on for 3 rows**
      - **3: Spare**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - SET_WIN_SIZE

SET_WIN_SIZE_0



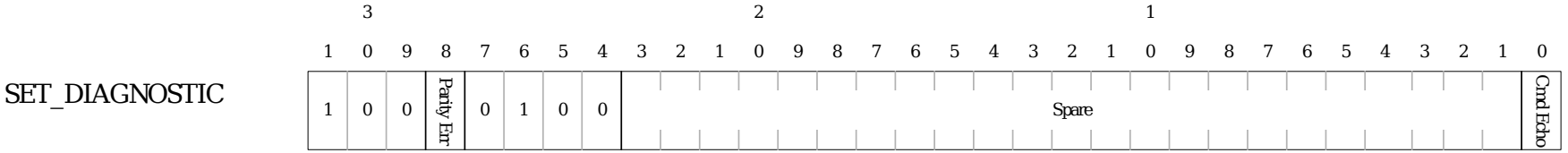
SET_WIN_SIZE_1



- **Description: The SET_WIN_SIZE Commands are used to control the science, acquisition and engineering mode window sizes.**
- **Modes: Science, Acquisition, Engineering**
- **Constraints:**
  - **These sizes can be set just once for every 4096 row period.**
  - **The sizes are valid for all CCD Halfs under control of the CCX/AP IF Controller.**
  - **Both the SET_WIN_SIZE_0 and SET_WIN_SIZE_1 commands must follow the SET_FRAME_DELAY command.**
  - **One occurrence of each command per command buffer.**

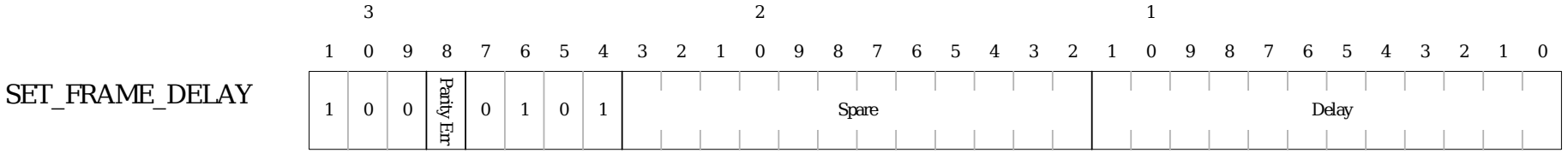
- **Fields:**
  - **Size Vertical - number of rows per window**
    - **12 bits**
    - **Range Science Mode**
      - **8 to 30 rows**
    - **Range Acquisition Mode**
      - **8 to 600 rows**
    - **Range Engineering Mode**
      - **1 to 4096 rows**
  - **Size Horizontal - number of columns per window**
    - **10 bits**
    - **Range Science Mode:**
      - **16 to 60 columns - must be even if the window command selects unbinned data collection**
    - **Range Acquisition Mode:**
      - **8 to 600 columns**
    - **Range Engineering Mode:**
      - **1 to 1024 columns**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - SET_DIAGNOSTIC



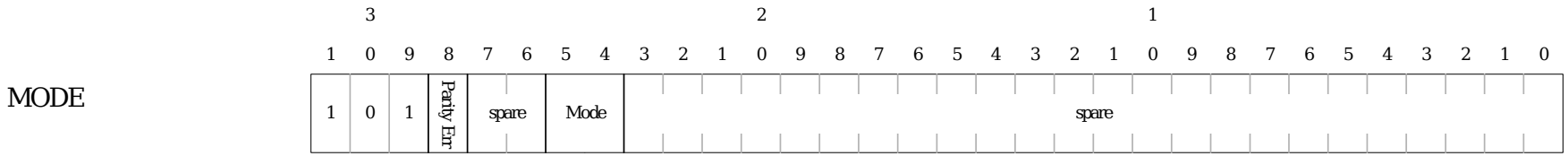
- **Description: The SET_DIAGNOSTIC command is used to control the diagnostic functions of the Instrument.**
- **Modes: Science, Acquisition, Engineering**
- **Constraints:**
  - **This command must immediately follow a FAT 0 Command.**
  - **One occurrence of each command per CCD Half.**
- **Fields:**
  - **Cmd Echo - Control Command Echo**
    - **1 Bit**
    - **Range**
      - **0: No Command Echo**
      - **1: Perform Command Echo**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - SET_FRAME_DELAY



- **Description: The SET_FRAME_DELAY command is used to control the timing of the command buffer transition (I.e. start of virtual frame). The delay will be will be performed between the currently active command buffer and the activation of the command buffer containing the frame delay command.**
- **Modes: Science, Acquisition, Engineering**
- **Constraints:**
  - **This command must immediately follow the SET_TDI_RATE command.**
  - **One occurrence of each command per command buffer.**
- **Fields:**
  - **Delay - Command Buffer (virtual frame) delay**
    - **12 Bits**
    - **Range**
      - **0: No delay**
      - **1 to 4095: Number of row intervals to delay**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - MODE



- **Description: The MODE command is used to set the data collection mode of the CCD digital and analog electronics.**
- **Mode: Science, Acquisition, Engineering**
- **Constraints:**
  - **This command must be specified as the first command for each command buffer sequence.**

- **Fields:**
  - **Mode - Mode selection**
    - **2 bits**
    - **Range**
      - **0: Engineering**
      - **1: Acquisition**
      - **2: Science**
      - **3: Spare**
  - **Parity Err - Parity Error Flag**
    - **1 bit**
    - **Range:**
      - **0: Mandatory on Control, no error in echo**
      - **1: Parity error in echo**

CCD Control - Science Mode Control Sequence

- Science Mode CCD Control Sequence Concept
  - MODE (Science)
  - SET_FRAME_DELAY
  - SET_WIN_SIZE_0
  - SET_WIN_SIZE_1
  - CCD_HALF_SELECT
  - SET_FAT_0
  - SET DIAGNOSTIC
  - WINDOW
  - STAR_ID
  - WINDOW
  - STAR_ID
  - CHARGE_INJECTION
  - CHARGE_ AMPLITUDE
  - WINDOW
  - STAR_ID
  - CHARGE_INJECTION
  - CHARGE_ AMPLITUDE
  - :
  - CCD_HALF_SELECT
  - SET_FAT_0
  - SET DIAGNOSTIC
  - WINDOW
  - STAR_ID
  - CHARGE_INJECTION
  - :
  - :
  - END_OF_DATA

- Constraint Summary
  - Buffer load should commence immediately after receipt of the Buffer_Ready signal
  - Buffer load time should not exceed 400 milli-seconds after receipt of Buffer_Ready signal
  - All commands for a CCD-half should be grouped together and start with a CCD_HALF_SELECT command
  - The address used in the CCD_HALF_SELECT command is dependent the CCD_HALF
  - Each WINDOW command must be immediately followed by an associated STAR_ID command
  - Each CHARGE_INJECTION command must be immediately followed by an associated CHARGE_AMPLITUDE command
  - The CCX/AP IF Controller maintains a row count that ranges from 0 to 4095. This count identifies the data output row (“bottom”) of the CCD.
  - The start row number of the WINDOW command represents the row # when the first segment of window data is taken from the “bottom” of the CCD.
  - When the row number of the CHARGE_INJECTION command matches the CCX/AP IF Controller row count, then a charge injection segment is introduced at the “top” of the CCD.
  - The WINDOW and CHARGE_INJECTION commands do not need to be sorted relative to row or column.

CCD Control - Acquisition Mode Control Sequence

- **Acquisition Mode CCD Control Sequence Concept**
  - MODE (Acquisition)
  - SET_FRAME_DELAY
  - SET_WIN_SIZE_0
  - SET_WIN_SIZE_1
  - CCD_HALF_SELECT
  - SET_FAT_0
  - SET DIAGNOSTIC
  - WINDOW
  - STAR_ID
  - CCD_HALF_SELECT
  - SET_FAT_0
  - SET DIAGNOSTIC
  - WINDOW
  - STAR_ID
  - END_OF_DATA

- **Constraint Summary**
  - A limit of 2 acquisition windows (I.e. 600 x 600) can be requested from a single CCX/AP IF Controller over a 4096 row period.
  - The Windows can be on the same CCD Half.
  - Buffer load time should not exceed 400 milli-seconds after receipt of Buffer_Ready signal
  - All commands for a CCD-half should be grouped together and start with a CCD_HALF_SELECT command
  - The address used in the CCD_HALF_SELECT command is dependent the CCD_HALF
  - Each WINDOW command must be immediately followed by an associated STAR_ID command
  - Each CHARGE_INJECTION command must be immediately followed by an associated CHARGE_AMPLITUDE command
  - The CCX/AP IF Controller maintains a row count that ranges from 0 to 4095. This count identifies the data output row (“bottom”) of the CCD.
  - The start row number of the WINDOW command represents the row # when the first segment of window data is taken from the “bottom” of the CCD.
  - When the row number of the CHARGE_INJECTION command matches the CCX/AP IF Controller row count, then a charge injection segment is introduced at the “top” of the CCD.

CCD Control - Engineering Mode Control Sequence

- **Engineering Mode CCD Control Sequence Concept**
  - **MODE (Engineering)**
  - **SET_FRAME_DELAY**
  - **SET_WIN_SIZE_0**
  - **SET_WIN_SIZE_1**
  - **CCD_HALF_SELECT**
  - **SET_FAT_0**
  - **SET DIAGNOSTIC**
  - **WINDOW**
  - **STAR_ID**
  - **END_OF_DATA**

- **Constraint Summary**
  - **Total number of pixel data that can be selected is limited to: TBD**
  - **Multiple windows can be requested, but are limited to TBD windows.**
  - **Data collection is limited to a single CCD Half.**

CCD Control Stars/FPA and Max Data Rate

- CCX/AP IF Controller Card will support 1023 requests per CCD half:
  - 1023 max_requests/CCD_half * 26 CCD_Half/FPA = 26,598 max_requests/FPA
  - Assuming: 2 requests per star (1 CHARGE_INJECTION and 1 WINDOW) then:
    - 13,299 max_stars/FPA
  - 1023 max_requests/CCD_half * 12 CCD_Half/CCX_AP_IF = 12276 max_requests/CCX_AP_IF
  - Assuming: 50% CHARGE_INJECTION and 50% WINDOW requests then the max data load per interface is:
    - 4 command buffer set commands
    - 12 CCD_HALF_SELECT
    - 12 * 2 CCD Half set commands
    - 6138 CHARGE_INJECTION + 6138 CHARGE_GAIN
    - 6138 WINDOW + 6138 STAR_ID
    - 1 END_OF_DATA
    - For a total of 24,593 commands * 32 bits = 786,976 bits
    - Given a max-load time of .4 seconds then: 786,976 bits / .4 seconds = 1,967,440 bits/second

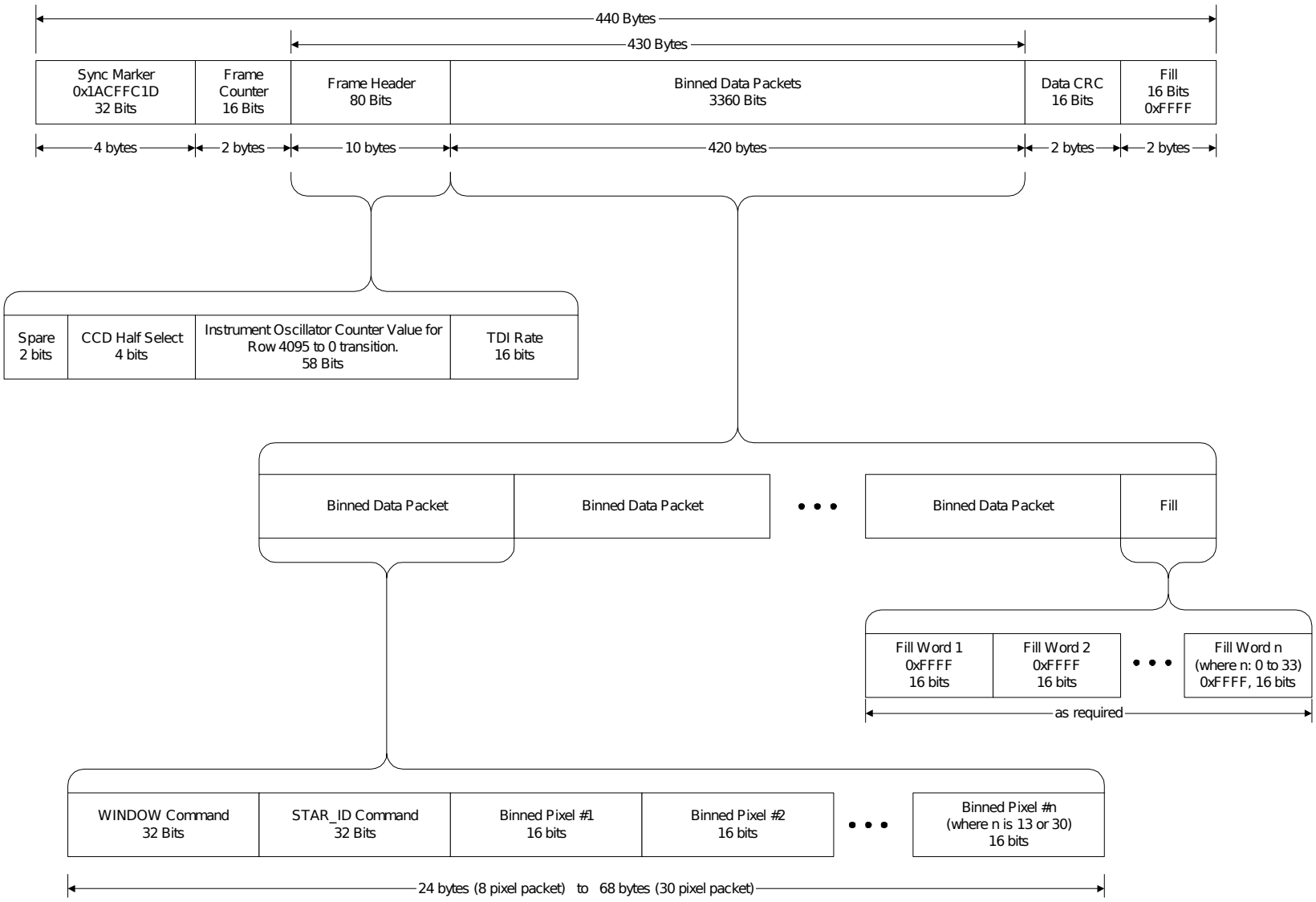
Buffer Ready Interface

Buffer Ready Signal

- Each CCX/AP Interface controller card supports two command buffers
- Each command buffer will control the activity of all CCD halfs (12 or 2) under control of the interface card
- Each command buffer will support 1023 window and charge injection command requests per CCD half
- Each command buffer will control the activity of the CCD halfs for 4096 rows.
- While one command buffer is actively controlling the CCD activity the other command buffer is available for data output, clearing memory, command load, window expansion and sorting
- When a command buffer is actively controlling the CCD it will be used for controlling the analog processing for data collection.
- Command buffer utilization will be exchanged at the transition between row 4095 and row 0
- The buffer ready signal will be raised when the buffer becomes available for loading and will be removed when the buffer is no longer available for loading (load time expiration or END_OF_DATA command).
- The buffer ready signal will be issued at a rate equivalent to 4096 rows (approximately every 2 seconds).

Binned Data Interface

Binned Data - Frame Format



Binned Data - Frame Utilization

- If all binned packets contain 13 values then:
  - Binned packet size is 34 bytes
  - 12 Binned packets (408 bytes) will fit in the available 420 bytes
  - 6 fill words (12 bytes) are required

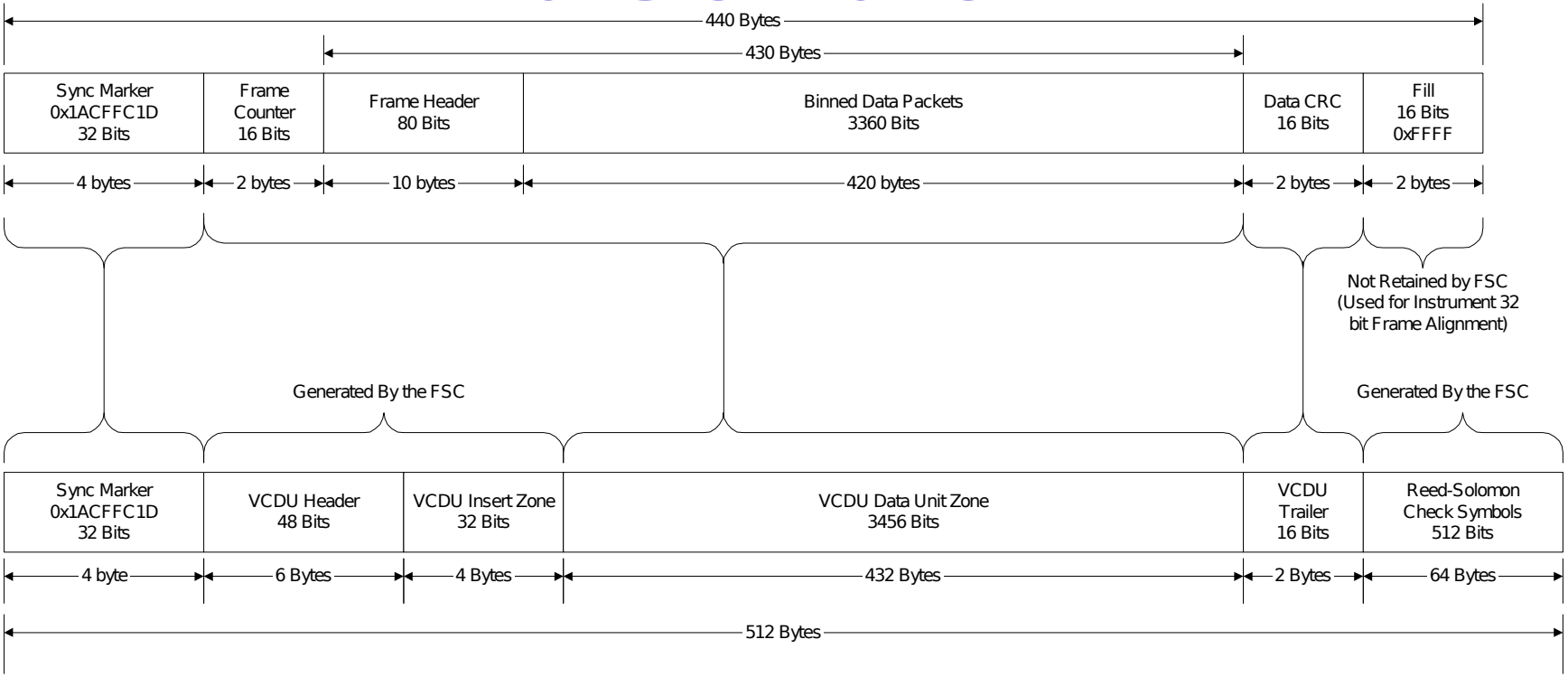
- If all binned packets contain 30 values then:
  - Binned packet size is 68 bytes
  - 6 Binned packets (408 bytes) will fit in the available 420 bytes
  - 6 fill words (12 bytes) are required

- In a frame containing a mixture of binned packets sizes then:
  - Binned packet sizes are 34 and 68 bytes
  - Number of binned packets can range from 6 to 11
  - 6 words (12 bytes) or 23 words (46 bytes) of fill will be required

- Last frame of from the data buffer collection from a CCX/AP IF Controller will contain from 1 to the max number of packets. Fill data will be used as required.

Binned Data FRAME to Downlink VCDU Transformation

Instrument Binned Data Frame



FAME Sync Marker and VCDU Downlink Format

Binned Data Interface Max Data Rate

- Each CCX/AP IF Controller Handles either 12 or 2 CCD Halfs
- Assume maximum utilization of 511 stars per CCD Half per 4096 rows
- Assume Binned Data Transfer must be performed within 500 milliseconds

- Case: All stars binned to 13 values, 12 CCD halfs
  - (12 CCD_Halfs * 511 Stars/CCD_Halfs) / 12 Stars/Frame = 511 Frames
  - (511 Frames * 440 bytes/Frame * 8 bits/byte) / .5 seconds = 3,597,440 bits/sec

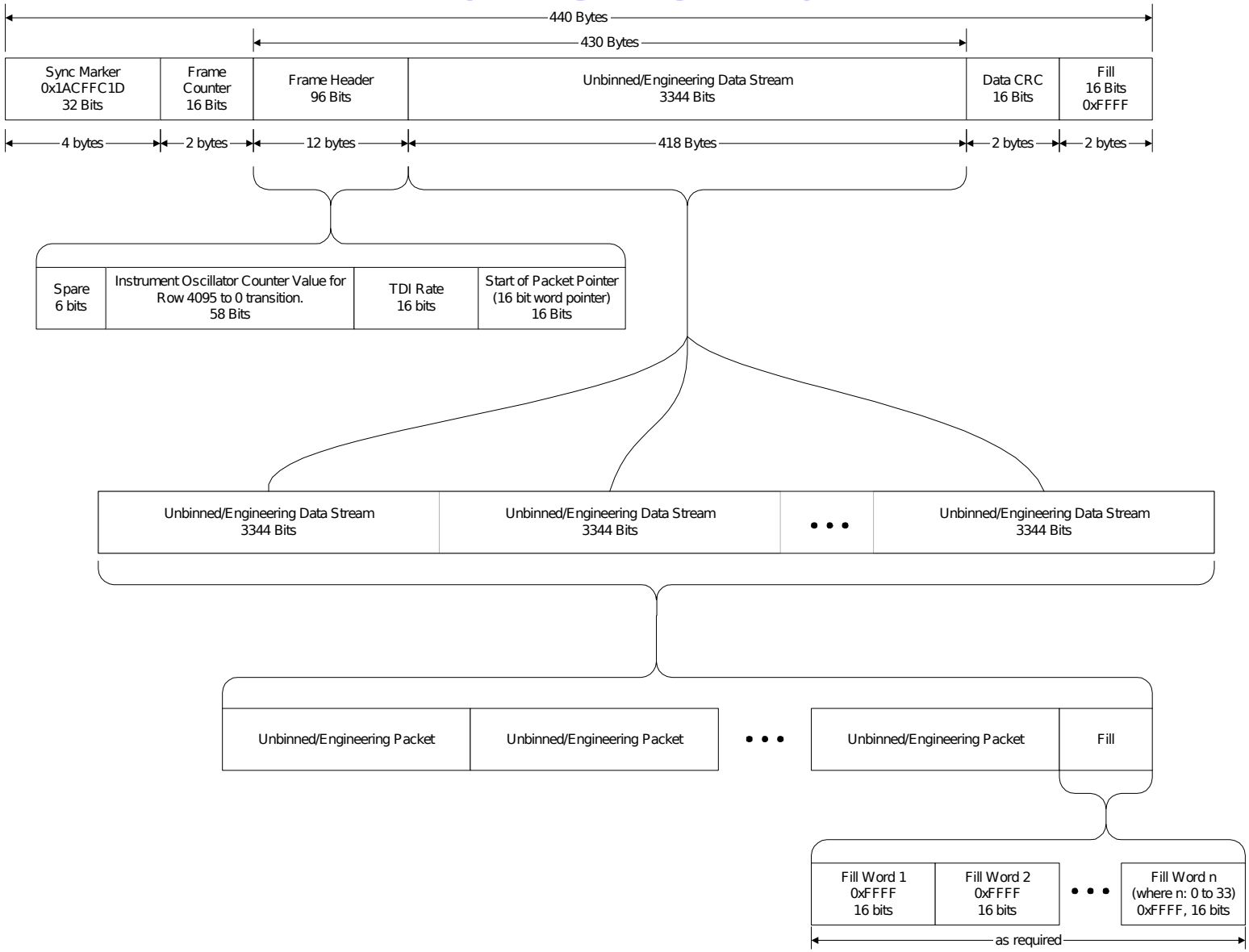
- Case: All stars binned to 30 values, 12 CCD halfs
  - (12 CCD_Halfs * 511 Stars/CCD_Halfs) / 6 Stars/Frame = 1022 Frames
  - (1022 Frames * 440 bytes/Frame * 8 bits/byte) / .5 seconds = 7,194,880 bits/sec

- Case: All stars binned to 13 values, 2 CCD halfs
  - (2 CCD_Halfs * 511 Stars/CCD_Halfs) / 12 Stars/Frame = 86 Frames
  - (86 Frames * 440 bytes/Frame * 8 bits/byte) / .5 seconds = 302,720 bits/sec

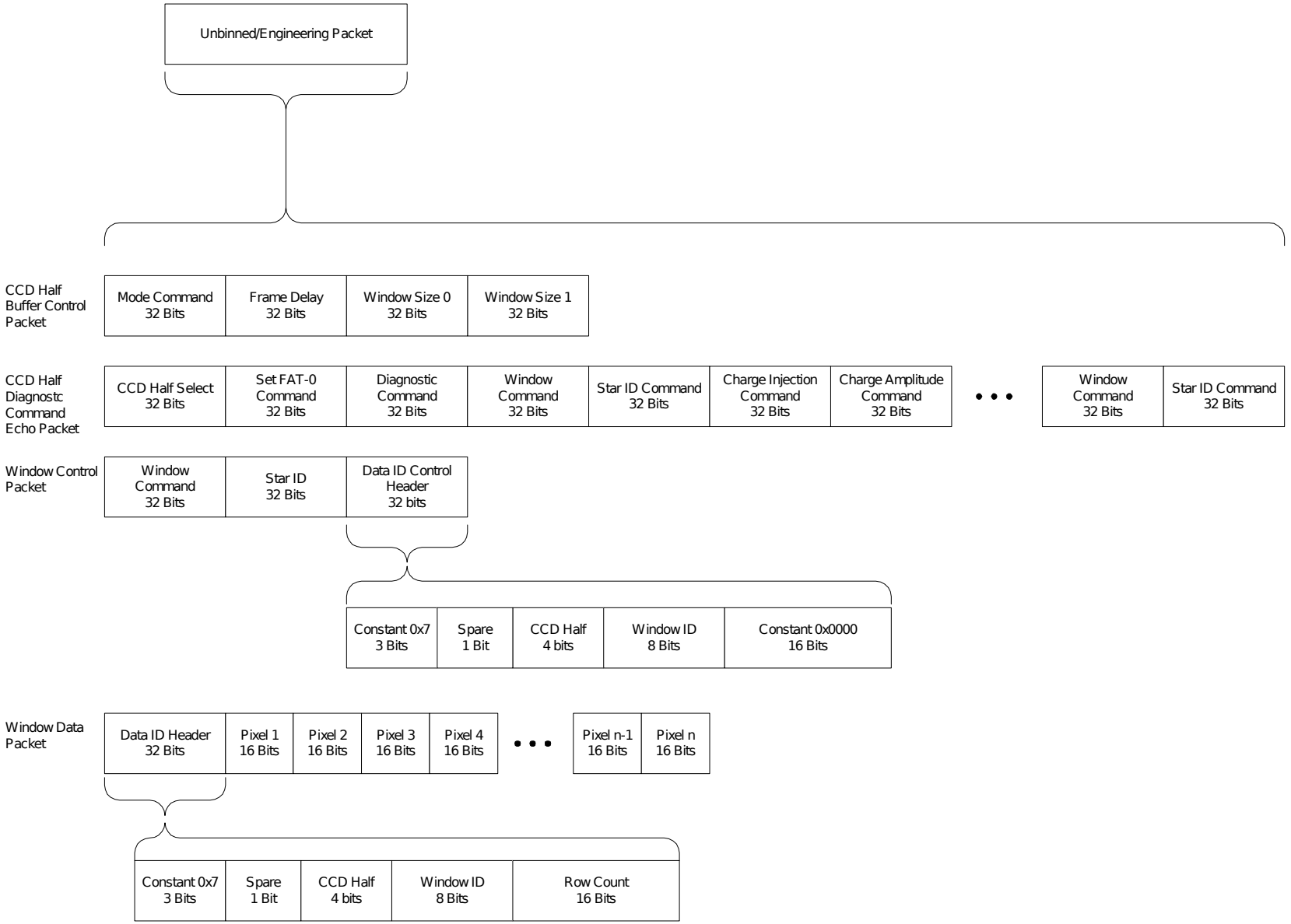
- Case: All stars binned to 30 values, 2 CCD halfs
  - (2 CCD_Halfs * 511 Stars/CCD_Halfs) / 6 Stars/Frame = 171 Frames
  - (171 Frames * 440 bytes/Frame * 8 bits/byte) / .5 seconds = 601,920 bits/sec

Unbinned/Engineering Data Interface

Unbinned/Engineering Data - Frame Format



Unbinned/Engineering Data - Packet Format

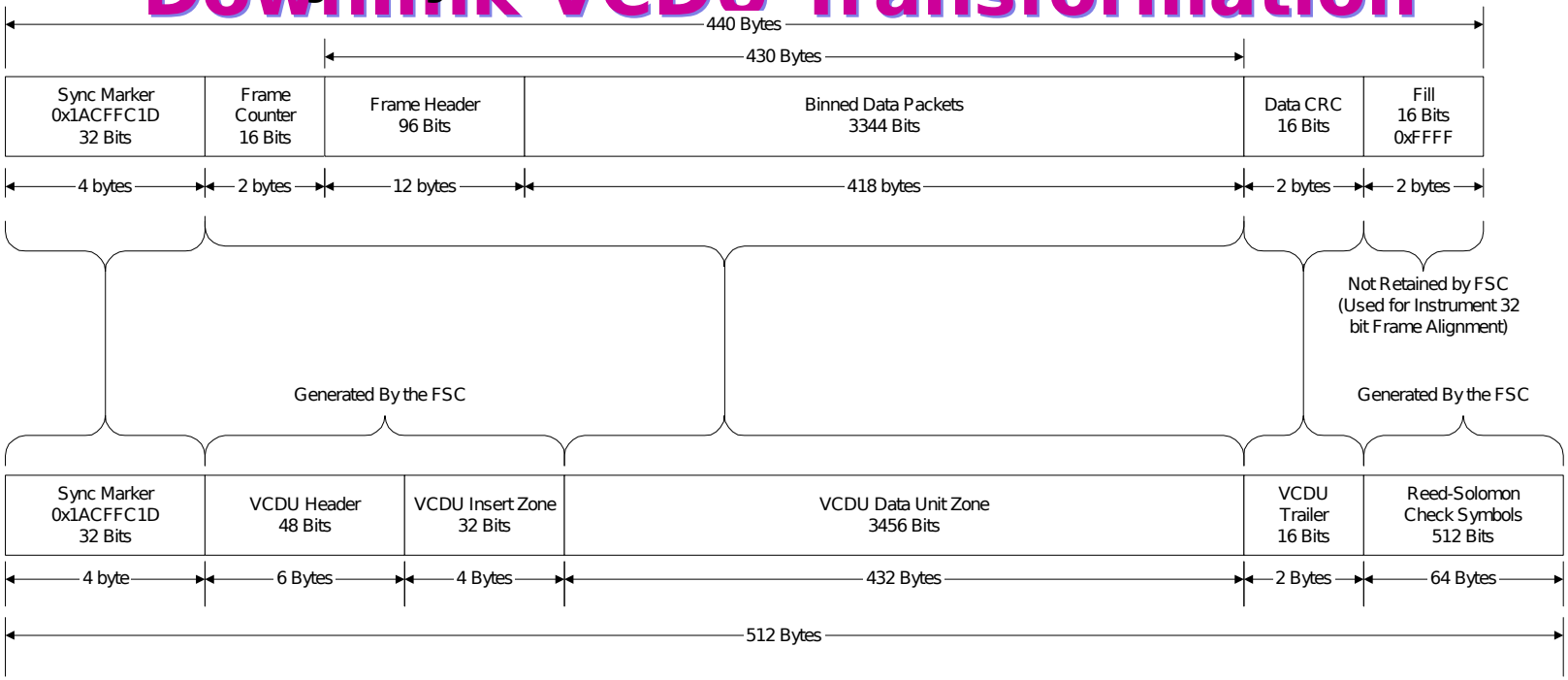


Unbinned/Engineering Data - Frame Utilization

- **Details - TBD**

Unbinned/Engineering Data FRAME to Downlink VCDU Transformation

Instrument Unbinned/Engineering Data Frame



FAME Sync Marker and VCDU Downlink Format

Unbinned/Engineering Interface - Maximum Data Rates (1 of 2)

- **Science Mode – Unbinned Data:**
  - **Unbinned window rows are sent when received**
  - **Maximum data rate is dependent on the maximum number of unbinned windows supported per CCD half over 4096 rows.**
  - **Maximum (average) data rate is dependent on the unbinned/engineering data format**

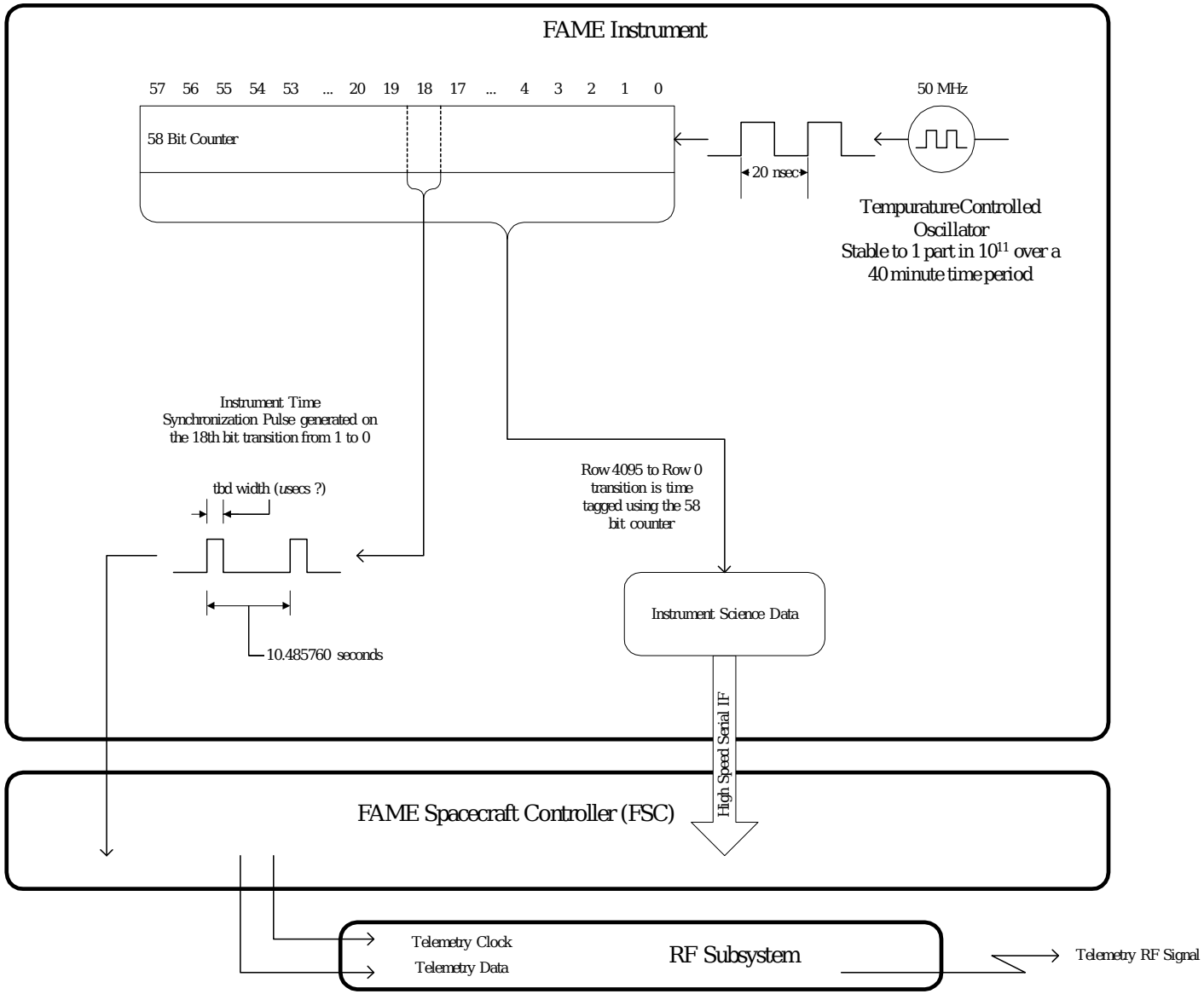
- **Acquisition Mode:**
  - **Acquisition window data is stored while the buffer is active and then forwarded to the FSC immediately after buffer transition.**
  - **Maximum acquisition windows per CCX/AP IF Controller is 2. The maximum window request size is 600 x 600. This results in 600 rows x 300 columns of pixels (due to 2d reduction). Total is 180,000 pixels or 360,000 bytes of pixel data.**
  - **Maximum data transfer per CCX/AP IF Controller is dependent on the unbinned/engineering data format**

Unbinned/Engineering Interface - Maximum Data Rates

- **Engineering Mode:**
  - **Engineering mode window data is stored while the buffer is active and then forwarded to the FSC immediately after buffer transition.**
  - **Maximum engineering data captured per CCX/AP IF Controller is no greater than 1024 x 1024 pixels (will be slightly less). Total will be no greater than 1,048,576 pixels or 2,097,152 bytes of pixel data.**
  - **Maximum data transfer per CCX/AP IF Controller is dependent on the unbinned/engineering data format.**
  - **FSC capabilities may be more constraining than the CCX/AP IF Controller with respect to total number of pixels that can be handled for a single buffer's worth of engineering data.**
  - **Given preliminary unbinned/engineering data format and one 1024 x 1024 engineering window, then the total data that requires transmission per buffer is:**
    - **16 bytes of control header**
    - **12 bytes of window header**
    - **4096 (1024 x 4) bytes of packet header**
    - **2,097,152 (1024 x 1024 x 2) bytes of pixel data**
    - **Total is: 2,101,276 bytes of data**
    - **At 418 bytes of data per frame, gives 5,027 frames**
    - **At 440 bytes total (included overhead) per frame, gives 2,211,880 bytes transferred**
  - **With a 12.5 MHz clock and assuming 1 clock between 64 bit words, then the transfer time required is 17,971,525 clock cycles or ~1.44 seconds.**
  - **FSC can support 2,097,152 (1024 x 1024 x 2) bytes of data or 4766 frames of data at 440 bytes per frame.**
    - **Given the preliminary format, the number of pixels that can be handled by the FSC is approximately 993,280 pixels (or 1024 x 970).**
    - **At 4766 frames per buffer, the data transfer time (@ 12.5 MHz) is ~1.36 seconds.**

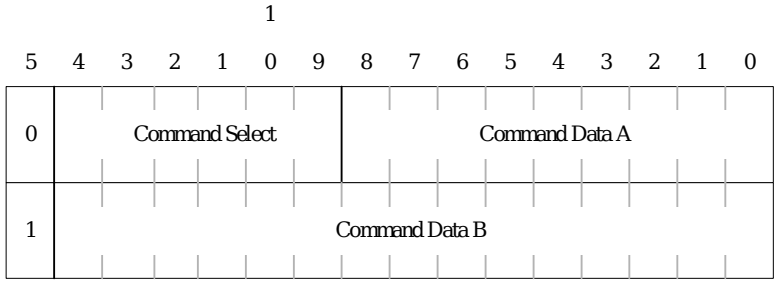
Time Synchronization Interface

Instrument Time Epoch Pulse Generation



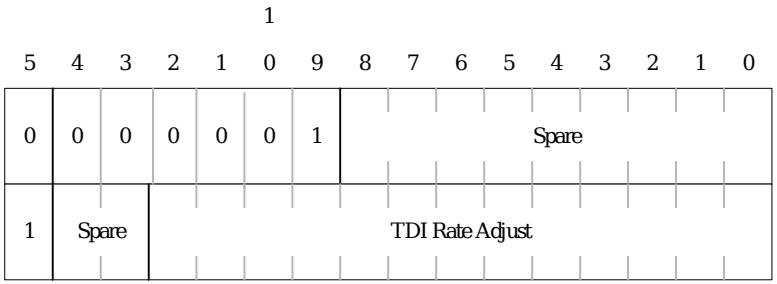
Command & Telemetry Interface

Command Interface



- The command interface is used as an interface to the following controller cards:
  - Heater and Housekeeping controller
  - LED and Focus Motor controller
- Each command is comprised of two command words.
- Each command word contains 16 bits.
- Command word fields:
  - Command word 0 ID:
    - 1 bit
    - Range: 0
  - Command Select:
    - 6 Bits
    - Range:
      - 0: Spare
      - 1: Set TDI Rate
      - 2 to 2047: Spare
  - Command Data A:
    - 9 Bits
    - Range:
      - Dependent on command select
  - Command word 1 ID:
    - 1 bit
    - Range: 1
  - Command Data B:
    - 15 Bits
    - Range:
      - Dependent on command select

Instrument Command - SET_TDI_RATE



- **Description: The SET_TDI_RATE Command is used to control the Instrument TDI rate. The base (minimum) TDI rate is set to the nominal TDI rate - 10%. The nominal TDI rate is specified as the number of instrument oscillator cycles per CCD line transition while at the nominal observatory spin rate. The TDI Rate used for data collection is equal to the base TDI rate + TDI Rate Adjust value. The intent is to allow TDI rate adjustment from the nominal TDI rate by plus or minus 10%.**

- **Constraints:**
  - **None**

- **Fields:**
  - **TDI Rate Adjust - oscillator ticks**
    - **13 bits**
    - **Range:**
      - **0 to 8191**

Actions & Issues

Action Items - Open (1 of 3)

- **Scott Horner/Peter Ogden/Marian Bumala/Mike Wagner/Science Team**
  - **Determine if there exists a constraint that limits to 2 the number of WINDOW and Charge Injection commands with the same Start Row number per a CCD half.**
    - **Updated Status 9/18/2001: The constraint is based on the limitation of the number of charge injection commands per row. There is no limitation of window starts and charge injections with the same row number. The limitation of the number of charge injection commands per row does imply a limitation of the number of windows that can start per line given an assumption that the number of rows between charge injection and the start of the window remains constant.**
  - **Updated Status 9/12/2001: Previous design, with faster TDI rate, limited the number of charge injection segments per row to two. Current TDI rate will allow for three - TBR (Marian to confirm).**
  - **Summary of current per row limitations in science mode:**
    - **11 total operations per row (binned windows, unbinned windows and charge injection) - TBR**
      - **Note 9/13/2001: If charge injection sorting is not required, then this limitation can be removed.**
      - **Updated Status 9/14/2001: Since charge injection command sorting is not required then the limit of 11 total operations per row is no longer necessary. Given the limits below, then the maximum total operations per row is 12.**
    - **8 binned windows**
    - **1 unbinned window**
    - **3 charge injection segments - TBR (Marian to confirm)**
    - **Do charge injection commands require sorting - No**
    - **Is the column numbering for charge injection the same column numbering used for window commands - Yes**
- **Peter Ogden**
  - **Provide a CCX/AP IF Controller buffer utilization timeline. Relate Row count with buffer utilization (clear, load, window expansion, sort, control, data collection, data output)**
- **Earl Aamodt/Peter Ogden/John Gambert**
  - **Determine whether one or two sets of I/F signals are required to support the FSC A/B sides**

Action Items - Open (2 of 3)

- **Peter Ogden**
  - **Characterize the output data rates**
  - **Updated Status 9/12/2001: Peter has concurred with the output data rate calculation approach presented in this package. Further evaluation of output data requirements is needed based on maximum star counts and the time duration available for buffer data output.**

- **Peter Ogden**
  - **Determine the maximum number of pixels that can be captured in engineering mode.**
  - **Updated Status 9/14/2001: Current estimate has the total number of pixels at no greater than: 1/4 * 1024 * 4096**

- **Science Team**
  - **Can the number of stars be limited to 511 per CCD Half per 4096 rows ?**
    - **Variances of the ratio of charge injection to windows commands does not necessarily limit the number of stars to 511 per CCD half.**

- **Brian Davis/Peter Ogden**
  - **Document CCX/AP IF Controller unbinned/engineering output data format.**
    - **Echo global commands (once per buffer)**
    - **CCD Half ID, Latched 58 bit count at buffer transition, TDI Rate (once per output data frame)**
    - **Window & Star ID command echo with each row of window data packet (possible row # update in window command)**
    - **Define timing of data flow per mode**
    - **Updated Status 9/18/2001: Preliminary unbinned/engineering output data format was presented in this package. Further review and discussion required.**

- **John Gambert/Peter Ogden**
  - **Should the CCX/AP IF Controller output interfaces support a CTS (from Bus), Frame Synch (from Instrument), Both or none.**
  - **Updated St 9/14/2001: The CCX/AP IF Controller binned data interface will not handle a CTS from nor generate a Frame Synch signal to the FSC. The binned data interface will utilize a Channel Active signal. The Channel Active signal will remain active for the download of the entire binned data contents of a buffer. The channel active signal will go active ~300 micro-seconds prior to data transmission. This delay will allow time for the FSC to finish downloading one frame from the unbinned/engineering interface prior to reception of data from the binned data interface. The unbinned/engineering interface will also utilize a channel active signal. For the unbinned/engineering IF, the channel active signal will remain active for the transmission of a single 440 byte frame. The channel active signal will remain idle for at least TBD clock cycles between frames. The channel active signal will lead data transmission by TBD (could be 0) clock cycles.**

Action Items - Open (3 of 3)

- **Brian Davis/John Gambert**
  - **Pertaining to the FSC SW/HW IF; What events should trigger notification of data available from the FSC unbinned/engineering data receive logic to the processor ?**

- **Science Team**
  - **What is the maximum number of unbinned windows that should be handled per second ?**

Action Items - Closed (1 of 2)

- **John Gambert**
  - **Provide RIU command and telemetry serial interface characteristics to LM ATC**
  - **Closed 9/6/2001: RIU specification provided to LM ATC**

- **Peter Ogden**
  - **Provide estimate of maximum number of commands per CCD half if Star ID storage and reporting is supported**
  - **Closed 9/6/2001: CCX/AP IF Controller can handle 1023 requests (combination of WINDOW and CHARGE_INJECTION)**

- **Brian Davis**
  - **Clarify relationship between CCX/AP IF Controller row count, WINDOW command and CHARGE_INJECTION command.**
  - **Close 9/10/2001: As contained in this package**

- **Mike Wagner/**
  - **Define science window size horizontal constraints (is 8 to 63 correct ?)**
  - **What is the format/units for the charge injection profile value and charge injection amplitude value**
  - **Closed 9/11/2001: Horizontal constraint is 8 to 63, Charge amplitude LSBit is 100 e/dn and the profile approach has been defined**

Action Items - Closed (2 of 2)

- **John Gambert/Peter Ogden**
  - **Determine if the QHSS interface can handle a 64 or 32 bit word vs 16 bit (based on enable signal encapsulation).**
  - **Closed/Updated 9/13/2001: FSC QHSS interface will handle 64 bit words.**

- **Mike Wagner**
  - **Confirm Charge Injection Profiles can overlap**
  - **Closed 9/12/2001: Charge injection profiles cannot overlap**

- **John Gambert**
  - **Is the inter-word delta for the serial interfaces 1 or 3 clock cycles ?**
  - **Closed 9/13/2001: 1 clock cycle**

- **John Gambert/Peter Ogden**
  - **What clock rate should be used for the CCD data output serial interfaces (12.5 Mhz, 10 MHz, other) ?**
  - **Closed 9/13/2001: Output clock rate of 12.5 MHz has been agreed to.**

Open Issues (1 of 3)

- **Continue definition and review of all identified bus/instrument data interfaces**
  - **Command Interface to the heater and housekeeping controller**
  - **Command Interface to the focus motor and LED control card**
  - **Telemetry interface from the heater and housekeeping controller**
  - **Unbinned/Engineering data format**

- **Review Instrument single point failures**
  - **Should there be two oscillators ? If so, how to select ?**

- **Review downlink bandwidth utilization**
  - **Updated Status 9/12/2001: Consideration is being given to stream the binned science data. Frame structure to support this is under consideration.**
  - **Header per frame**
  - **STAR_ID**
  - **Fill**

Open Issues (2 of 3)

- **Review need for Start/Stop capability for bright stars.**
  - **Updated Status 9/14/2001: Program discussion/review required.**
  - **Updated Status 9/17/2001: One approach for the start/stop capability is the introduction of a CCD half associated SET_START_STOP command. Even though this command is associated with a CCD half select, it will be applicable to both CCD half. The proposed SET_START_STOP command would support the following five parameters and the associated algorithm:**
    - **Initial_Row_Count: 12 bits, range from 0 to 4095**
    - **State_Of_Initial_Rows: 1 bit, 0 - off, 1 - on**
    - **Number_Of_Rows_On: 12 bits, range from 1 to 4096 (where a value of 0 represents 4096)**
    - **Number_Of_Rows_Off: 12 bits, range from 1 to 4096 (where a value of 0 represents 4096)**
    - **Sequence_Repeat: 11 Bits, range from 1 to 2048 (where a value of 0 represent 2048)**
    - **At the start of a new virtual frame, an intial number of rows, if any, will be set on or off. Then the row transition clock will be enabled for Number_Of_Rows_On then disabled for Number_Of_Rows_Off. This sequence will repeat until the virtual frame is complete or the Sequence_Repeat is reached. If the on/off cycle has been performed for Sequence_Repeat times, then the Row transition will remain enabled for the rest of the virtual frame.**
  - **Another approach is to provide a row transition control command that can be used to enable or disable row transitions at a particular virtual frame row number. The CCX/AP IF Controller could allow for TBD of these commands per CCD.**
  - **Updated Status 9/18/2001: Requirements, instrument capabilities and various approaches (listed or otherwise) must be reviewed at the program level.**

Open Issues (3 of 3)

- **Review the limitation that the TDI rate cannot be controlled outside of the nominal TDI rate +/- 10%.**
- **Review need for FAT-0.**
  - **Updated Status 9/14/2001: FAT-0 capability has been presented in this package. Program discussion/review required.**
- **Review need for threshold, column skip and row skip for the acquisition mode (I.e. data filtering by the CCX/AP IF Controller)**
  - **Updated Status 9/14/2001: Baseline is currently SW, however, the ability to extend data collection fully across 5 CCDs for acquisition could be considered if data filtering is considered.**
- **Should the buffer ready signal (Type B) be replaced by the CTS (Type A) signal (or vice versa) ?**
  - **Updated Status 9/17/2001: The buffer ready signal (Type B) is the clear to send signal. However, for the purposes of this presentation, the buffer ready signal (Type B) will be retained and the CTS signal identified in the CCD Control IF (Type A) will be removed.**
- **What is the CCD half numbering and what are the assignments of the CCDs per CCX/AP IF Controller with respect to the physical layout ?**
- **Review capability requirements related to extended pixels.**

Issues Addressed but Require Review (1 of 3)

- **Discuss bus/instrument time synchronization requirements/approach**
  - **Is the time epoch pulse and the row 4095/0 transition time tags enough ?**
    - **Updated Status 9/12/2001: Yes**
  - **Does the Bus need the frame synch signals**
    - **Updated Status 9/12/2001: No**

- **What is the state of the instrument control electronics after reset**
  - **Updated Status 9/13/2001: Default TDI rate (TBD) will be utilized after reset. While no commands are received for a CCX/AP IF Controller buffer, then no binned or engineering data will flow from that CCX/AP IF Controller.**
  - **What, if any, initialization sequences are required**
    - **Updated Status 9/12/2001: None**

- **What method will be used for CCX/AP IF Controller Card synchronization**
  - **Options:**
    - **No synchronization**
    - **One controller card will act as a master for frame synchronization**
    - **All cards will synchronize once to instrument time epoch pulse after reset**
    - **Frame synchronization will originate from oscillator control logic**
  - **Updated Status 9/18/2001: The instrument oscillator driven clock, CCD row synch and CCD frame synch (4096 rows) will be distributed to all CCX/AP IF Controller Cards. The oscillator logic will control the TDI_RATE. However, each card will retain an independent TDI row counter. The row counter will be set to zero at buffer transition. Buffer transition for an interface card will occur at a delay from the global frame synch. The SET_FRAME_DELAY command will control the delay per CCX/AP IF Controller Card. The delay can range from 0 to 4095 rows.**

Issues Addressed but Require Review (2 of 3)

- Should consideration be given to staggered synchronization for CCX/AP IF controller cards ?
  - Updated Status 9/14/2001: Current assessment of output data characteristics will require staggered synchronization of the CCX/AP IF Controller cards.
  - Could simplify the output data multiplexing
    - Updated Status 9/14/2001: Staggered synchronization is required to support output data multiplexing.
  - How to control staggered synchronization
    - Updated Status 9/14/2001: Processor controlled using the SET_FRAME_DELAY command.

- Should Parity be considered for the CCD control interface ?
  - Updated Status 9/12/2001: A parity bit will be added to all 32 bit CCD control commands (33 bits total per command).
  - Updated Status 9/14/2001: The CCD control interface will transmit data MSBit first, parity bit will be the last bit transmitted and parity will be odd.
  - How should errors be captured and reported
    - parity error count via housekeeping
      - Updated Status 9/12/2001: A parity error count will be available via housekeeping
    - parity bit in the command echo data captured in the downlink interface
      - Updated Status 9/12/2001: A parity error indication per CCD control command will be captured in the parity error field. Parity error per command can be checked when the commands are echoed (downlinked). Only Window, STAR_ID and global buffer commands are routinely echoed. The SET_DIAGNOSTIC command can be used to echo all CCD control commands.
    - Commands are ignored if a parity error occurs. Previous mode and set values from previous commands will be used in the presence of parity errors - TBR.

Issues Addressed but Require Review (3 of 3)

- **Should the TDI rate change be time tagged and/or synchronized to an event ?**
  - **Updated Status 9/18/2001: TDI rate changes will be synchronized with the frame synch event generated by the instrument oscillator control logic.**

- **TDI_RATE:**
  - **Issue updated 9/14/2001: The three CCX/AP IF Controller cards must be synchronized with respect to line synch to minimize noise. This requires a distributed line synch and a common TDI rate. The control logic for the TDI rate will be co-resident with the oscillator and oscillator counter logic. The TDI rate will be set via the command interface from the FSC to the Focus Motor and Housekeeping Controller.**
  - **Is TDI rate set for each CCX/AP IF Controller card independently ? - No.**
  - **When should the TDI_RATE command be sent ?**
    - **Updated Status 9/18/2001: At anytime, the TDI rate will take affect after the next frame synch event.**
  - **Should the output data header also contain the TDI Rate ? - Yes**
  - **What is the format/units of the TDI rate - Oscillator ticks from 0 to 8192.**

Closed Issues

- **Mode**
  - **What command sequence should be used to switch modes - each virtual frame will be explicitly commanded to a mode**
  - **What set commands are valid for what modes and when should they appear in the sequence - as now defined in this package**
  - **What commands are valid for engineering mode - as now defined in this package**

- **Should the instrument provide debug capability by allowing for the downlink of CHARGE_INJECTION and CHARGE_AMPLITUDE commands.**
  - **Closed 9/12/2001: Yes, the SET_DIAGNOSTIC command can be used to force echo (downlink) of all CCD Control commands.**